

Patent Application

Title Of The Invention

METHOD FOR CURING CYANOACRYLATE ADHESIVES

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BACKGROUND OF THE INVENTION

1. *Field of the Invention*

This invention relates broadly to a new method of curing stabilized cyanoacrylate adhesives coincidentally with their application to a substrate, particularly with reference to medical procedures using such adhesives and new devices for using the method.

2. *Description of the Prior Art*

Medical interest in cyanoacrylate polymers was apparent in the mid-nineteen sixties as evidenced by numerous reports on its use as a tissue bonding agent. Collins, et al reported on the effectiveness of homologous chain cyanoacrylates for bonding of biological substrates (1,2). They observed high rates of polymerization with longer chain esters than the methyl or ethyl monomers. There appeared to be more biocompatibility with the longer chains as noted by the ease of spreading monomer films on biosubstrates. This contrasted with in vitro polymerizations where the lower homologues reacted much faster. There was particular interest in the degradation of these polymers as they related to possible harmful effects that would preclude their use in surgery. Woodward, et al (3) reported histotoxicity of these monomers in rat tissue. The study involved in situ polymerization of three cyanoacrylate monomers: methyl, hexyl, decyl. It was reported that histotoxic effects were greatest with methyl and decreased with the other two monomers.

The same group reported on the use of radioactive methyl cyanoacrylate for monitoring routes for the loss of the polymer (4, 5). Results indicated that the polymer was degraded and excreted principally through the urine and feces. Analysis of the animal's organs revealed no signs of radioactivity. This implied no degradation products were incorporated into any of the animal's metabolic pathway. By analogy to polyvinylidene cyanide, they noted that the cyanoacrylate polymer degraded in the presence of water and more so in the presence of bases. The first observed degradation product turned out to be one of the starting materials, i.e., formaldehyde. In vitro studies have shown that the polymers degrade via hydrolytic scission in homogeneous as well as heterogeneous conditions (6). These degradation products were confirmed to be formaldehyde and the corresponding cyanoacetate. The conditions of solution degradation affected the consequent rates, namely, under neutral conditions rates

1 decreased as the homologous series was ascended while alkaline conditions increased all
2 rates.

3 The same study reported that the hydroxyl group was evident in the polymer as
4 the initiating species. This was concluded from infrared spectral data that displayed
5 hydroxyl group absorption at 3600 cm^{-1} . Further support for this is the noted
6 suppression of the OH as water is replaced with methanol and the observed methoxy
7 absorption at 1100 cm^{-1} . Preferential initiation was shown to occur with NH_2
8 containing substances such as pyridine, cysteine, alanine, and glycine in aqueous
9 solutions. This suggested that in vivo adhesion was more than a mechanical interlocking
10 of the solid polymer with the tissue. This appears to be the case as it was noted that
11 typical polymer solvents were not effective in solvating tissue-bound polymer.

12 From this it would appear that in vivo studies of degradation do not necessarily
13 correspond to in vitro conditions. Part of the degradation mechanism relies on the
14 solution of polymer for hydrolytic scission. The chemical bonding of the polymer
15 excludes this surface from hydrolytic activity. A mechanism of degradation was proposed
16 that suggests an action similar to unzipping in acrylics, however, the difference being that
17 the monomer is not regenerated. The proposed mechanism necessitates the presence of
18 the hydroxyl as well as the presence of water.

19 An unusual effect was reported regarding the aqueous degradation of isobutyl
20 cyanoacrylate (7). Of the monomers tested (methyl, propyl, butyl, isobutyl, heptyl ,
21 octyl), it was the only one that degraded more rapidly than any of the unbranched
22 homologues, with the exception of the methyl.

23 A second study reported that in vivo experimentation give credence to the chain
24 scission mechanism by hydrolysis (8). When beta-(14) carbon tagged cyanoacrylate is
25 implanted in rats, radioactive urea is isolated from urine. This suggests that tagged
26 formaldehyde is released, converted to carbon dioxide and in turn reacts with ammonia to
27 produce urea (9).

28 Rates of degradation on ethyl, butyl, and hexyl cyanoacrylates were evaluated
29 with regards to molecular weights, concentrations, and side chain structures (10). The
30 method employed buffered systems of pH ranges from 5.97 to 7.88. As expected, the
31 rates increased with increasing pH. Scanning electron microscopy of the degraded
32 polymer indicated that reaction occurs at the surfaces and not internally through

1 diffusion. It was postulated that the greater the length of the nalkyl side chain, the more
2 protection provided to the labile hydroxyl end of the polymer chain. This in turn would
3 provide greater resistance to degradation of the polymer. Degradation rates do in fact
4 correspond to chain length protection. The relative rates of degradation for hexyl, butyl,
5 and ethyl were, respectively, 1.0, 1.36, 9.55.

6 The same group reported on a study whereby degradation rates were retarded by
7 increasing the chain length of the polymer (11). Very small quantities of impurities in the
8 monomers had a significant impact on the final outcome of the degree of polymerization.
9 Further to this study, within the ethoxyethyl system, longer chain length enhanced the
10 degradation resistance of the resultant polymer.

11 A comparative study of ethyl cyanoacrylate and polyurethane in-situ generated
12 adhesives and coatings were reported in US patent 4,057,535. The study claimed the
13 superiority of the polyurethane structure due to high flexibility and compatibility with
14 the treated tissues. The single comparison was made with incised tissue and
15 consequent application between the wound edges. Inferiority of this application for
16 the cyanoacrylate was readily evident, but true topical applications were not
17 compared. Of eleven examples given, four were of a topical method, yet no data was
18 presented as no application of the ethyl or any other homologue was done
19 conjunctively for comparative efficacy. A further deficiency of this patent is the
20 practicality of use. No indication is given for a device to properly apply the two part
21 system and appears to indicate an at-site preparation.

22 Another patent, US 5,192,536 overcomes the apparent difficulty of 4,057,535
23 by taking preformed polyurethane and dissolving in a rapidly evaporating solvent
24 such as tetrahydrofuran. The composition is designed to form a "membrane-like cover
25 over the wound" and "assists in maintaining closure of the wound". Again no
26 comparative studies were reported.

27 US patent 3,995,641 presents the novelty of modified cyanoacrylates, namely,
28 carbalkoxyalkyl cyanoacrylates. These also are claimed to be useful for tissue
29 adhesives in surgical applications. The presumed superiority of these products was
30 attributable to the rapid hydrolytic decay and concurrent low degree of histotoxicity.
31 Since no data is presented regarding formaldehyde evolution it is presumed that the
32 hydrolysis mechanism does not scission the polymer to generate it.

1 US patent 5,254,132 discloses the use of a hybrid method of surgical
2 application of cyanoacrylates. It claims a combination of sutures and adhesive such as
3 to be mutually isolated from each other, but to both support the re-growth of the
4 tissue in the wound area. It addresses the issue of insuring no contact of adhesive in
5 the suture area so as to assure no inclusions of the cyanoacrylate. This method would
6 appear to be awkward and cumbersome and require a very effective and controlled
7 dispensing of the adhesive without contacting the suture. Additional concern is
8 indicated as a suggestion is made to employ a solvent (acetone) if any surgical
9 instrument happens to be bonded inadvertently to the treated area.

10 US patent 5,328,687 attacks the formaldehyde issue by incorporating a
11 formaldehyde scavenger such as sodium bisulfite. The various compositions were
12 evaluated via in-vitro experimentation. The examples presented all had a presumably
13 excessive level of scavenger. The representative compositions had loadings of 20% of
14 a scavenging agent that was designed to offset formaldehyde emissions that were at
15 0.1%. As indicated previously, in-vitro and in vivo conditions are not identical and
16 certainly not in this instance. The presented in-vitro conditions do not factor in the
17 dynamic conditions in living tissue. The surgically treated area would be under
18 continuous and changing fluids as the organ attempts to bring in the necessary
19 biocomponents to heal the traumatized tissue. As such, it would not be expected that
20 the scavenger/formaldehyde ratio would be maintained as it was in the in-vitro state.
21 It could be speculated that the use of such high loadings of any fluid solubilized
22 additives would contribute to greater formaldehyde emissions. This can be assumed to
23 be a consequence of dissolution of the additives resulting in cavities in the polymer
24 thereby promoting greater surface area for hydrolytic degradation.

25 US patent 5,403,591 concerns the use of cyanoacrylates for treatment of skin
26 irritations that progress to ulcerations. It would be assumed that these conditions
27 could be considered wound formations, e.g., see U.S. patent 3,995,641.

28 US patents 5928611, 5981621, 6099807, 6217603 describe methods of inducing
29 cure of cyanoacrylates by passing the adhesive through a porous applicator tip containing
30 substances that initiate the polymerization .

31 US patent 6143352 describes methods of altering the pH environment of
32 cyanoacrylates in order to attenuate or accelerate the rate of hydrolytic degradation by

uses of acid and alkaline additives. The formulation of acidic modifiers is problematic as they tend to inhibit the primary characteristic of these materials, namely, rapid cure on application to tissue. Data is presented on effects of acidic compositions on previously cured cyanoacrylates.

All of these methods rely on addition of various compositions to effect the accelerated cure onto the desired substrate. These may induce polymerization by creating a greater number of initiation sites and or orientation of the monomer for more facile polymerizations. Other plausible mechanisms can be evoked, but the fact remains that these materials become a part of the composition. As such these chemical inclusions may elicit unfavorable reactions in the cured state. In particular, the use of pH-based accelerators can now contribute to the alkaline hydrolysis of the cyanoacrylate polymer.

This is particularly undesirable in medical applications of the cyanoacrylates as the hydrolysis results in the evolution of formaldehyde. A certain level of formaldehyde can be tolerated by tissue as it is able to dispose of reasonable concentrations. A solution to this was to increase the chain length of the cyanoacrylate monomer side group and in particular that it be alkyl so as to impart hydrophobic character to the resulting polymer.

The current and prior art has been able to achieve a synthesis of the octyl cyanoacrylate at economic levels for applications in the medical field, although improbable for uses in commercial applications due to reaction yields. A number of methods have been attempted to improve yields (12). The variables looked at included: azeotropes, temperature and formaldehyde/cyanoacetate ratio. Other methods have also included assessment of different catalysts for the condensation reaction. Regardless of the methods tried, yields become increasingly smaller as the cyanoacetate pendant group becomes larger.

A reported attempt to improve yields is reported in U.S. patent 6,245,933. This method attempts to avoid yield losses by producing the high yield cyanoacrylate prepolymers of the lower homologues (methyl & ethyl) and then proceed through a transesterification with a longer chain alcohol such as the octyl. Three reported examples with 2-octanol gave yields ranging from 21.8% to 36.2% of crude monomer.

From this, it can be seen that high yields are difficult and no doubt subsequent workup to medically acceptable products result in even lower product output. The difficulty with methods such as above, is the undesirable side products which are difficult

1 to remove from the main stream. In particular, it is difficult to achieve complete
2 transesterification reactions on polymeric moieties because of steric obstruction. As a
3 consequence, purity is compromised as the initial cyanoacrylate prepolymer is not
4 completely reacted and the lower homologue co-distills with the desired product.

5 Other additives have been used to attenuate various properties, such as modulus
6 (elasticity), viscosity, thermal resistance, etc. Each and every additive becomes a
7 substance that must be removed by the surrounding tissue, which generally do not assist
8 in recovery of the damaged area. In that regard, the addition of these additives must
9 factor the property improvement against the effect on tissue compatibility.

10 OBJECTS

11 A principal object of the invention is the provision of a new method for curing of
12 cyanoacrylate adhesives.

13 A further object is the provision of such curing methods that minimize presence
14 of contaminants and extraneous additives in the resulting cured adhesives with particular
15 reference to use in medical procedures.

16 Additional objects include:

17 1. Enhancing the cure speed of stabilized cyanoacrylate adhesives by
18 destabilization treatment that removes stabilizers from them coincidently with their
19 application onto a substrate.

20 2. The provision of new cyanoacrylate adhesives curing methods that allow for
21 greater levels of stabilizers therein to be formulated to provide improved shelf life while
22 not lowering speed of cure upon application.

23 3. Providing for greater latitude of storage of cyanoacrylate adhesives in
24 packages with less regard for handling thereof.

25 4. Enhancing the cure speed of cyanoacrylate adhesives by a destabilization
26 treatment that purifies such adhesive coincidently with the application onto a substrate.

27 5. Producing improved cured cyanoacrylate adhesives that exhibit greater
28 biocompatibility as a consequence of modified polydispersity, especially such adhesives
29 that exhibit attenuated degradation of the polymer thereby exposing tissue contacting the
30 adhesive to lower levels of formaldehyde.

6. The provision of improved cyanoacrylate adhesives curing methods that enable the use of difunctional and/or multifunctional cyanoacrylates to optimize properties such as elasticity, porosity, cohesive strength and degradation rates.

7. The provision of improved cyanoacrylate adhesives curing methods that allow for greater degree of freedom in concentration of stabilizers without affecting the final chemical characteristics of such adhesives.

8. The provision of improved cyanoacrylate adhesives curing methods that allow for formulating unadulterated adhesives containing no plasticizers while achieving the elastomeric properties necessary for bonded substrates undergoing multidimensional stresses.

9. The provision of unique devices for use in carrying out the new method of the invention.

Other objects and further scope of applicability of the present invention will become apparent from the detailed descriptions given herein; it should be understood, however, that the detailed descriptions, while indicating preferred embodiments of the invention, are given by way of illustration only, since various changes and modifications within the spirit and scope of the invention will become apparent to those skilled in the art from such descriptions.

SUMMARY OF THE INVENTION

These objects are accomplished in accordance with the invention by the provision of a method for curing reactive monomeric cyanoacrylate oligomers to undergo macromolecular formations via appropriate destabilization coincidently with their application to a substrate. Such destabilization chemically and physically removes stabilizing agents so the new method allows for greater levels of stabilizers to be formulated for improved shelf life and not result in slower curing speed upon application to a substrate. Further, this allows for greater latitude of storage in various packages with less regard for product handling.

Cyanoacrylate adhesives that exemplify this invention comprise one or more monomers having the following general structure:



Without encumbering the body of this patent with specific examples of moieties, reference is made to the numerous patents delineating the myriad of groups that can be

represented by the moiety designated as R. These are therefore intended to define and be included by general reference to such prior art and by those knowledgeable thereof.

This invention achieves this goal by removing stabilizers in cyanoacrylate adhesives coincidentally with their application to substrates thereby making the resultant purified compositions highly susceptible to polymerizations as a result of contact with the substrates. In one embodiment for effectively using stabilized cyanoacrylate adhesives in accordance with the invention, they are stored in a device that houses a frangible ampoule containing such adhesives separate from particulate agent that removes stabilizers from the adhesive, but within the device. Alternatively, the frangible ampoule may contain the particulate destabilizing agent separate from the stabilized cyanoacrylate adhesive or both the stabilized cyanoacrylate adhesive and the particulate destabilizing agent may be contained in separate ampoules.

Such frangible ampoule containing devices may be constructed of any number of materials that can be shaped or molded or otherwise fabricated to contain the adhesive and ampoule. Also, it can be made from such materials as to provide a resilient wall capable of transmitting pressure to the frangible ampoule without loss of its containment properties. These application devices advantageously further comprise a filtering component and nozzle for application of the filtered and resulting destabilized adhesive to the substrate.

The application devices preferably are designed to apply the destabilized product in a continuous manner by appropriate removal of any destabilizing component. An example of such a device is one that incorporates a removable cartridge of the destabilizing agent with a reservoir of the appropriate adhesive feeding through the cartridge.

In a preferred embodiment, one of the above described devices containing isooctyl cyanoacrylate in the crushable ampoule and a weak base anion exchange resin such as "Ionac AFP329" (Sybron Chemicals, Inc.). The ampoule is crushed and contents are intermixed so as to optimize maximal contact with the isooctyl cyanoacrylate monomer for a short period of time. Upon achieving the desired consistency, the contents are then expressed through the appropriate filter and dispenser tip onto the substrate, specifically living tissue, mainly human or animal flesh and skin. The application is accomplished in such fashion as to prevent encapsulation of adhesive by any surrounding

1 tissue. Though ultimately these inclusions are degraded and excreted, it is most desirable
2 to minimize this occurrence to maximize reconstitution of the surrounding tissue. The
3 need to assure this minimization was noted in U.S. patent 3,667,472 which pointed out
4 the requisite to bridge the wound without diffusing into it. This was accomplished by
5 bringing the wound edges together followed by application so as to effect a bridging over
6 the wound to circumvent necrosis and irritation by this technique.

7 A second preferred embodiment utilizes the above described devices containing
8 isodecyl cyanoacrylate, weak base anion exchange resin, and an appropriate difunctional
9 cyanoacrylate to effect a composition capable of generating sufficient multiaxial strength
10 to maintain integrity of the healing tissue.

11 A third preferred embodiment utilizes the above described devices containing
12 isotridecyl cyanoacrylate and weak base anion exchange resin as the destabilizing agent.

13 A fourth preferred embodiment includes the above with combinations of
14 cyanoacrylate monomers to achieve control over the rate of hydrolytic degradation so as
15 to improve compatibility with tissue by control of formaldehyde emissions.

16 In preferred embodiments, the invention employs particulate ion exchange resins,
17 molecular sieves, zeolites, chelators, and/or alkaline solids, particularly alkali metal
18 carbonates, as destabilizing agents to remove stabilizers from solution in the
19 cyanoacrylate adhesives. Advantageously the size of these particulate destabilizing
20 agents will be of between Nos. 10 and 600 U.S. standard sieve series size and they will be
21 selected to produce destabilization of the cyanoacrylate adhesive within about 1 to 5
22 minutes of mixing the destabilizing agent(s) with the cyanoacrylate adhesive.

23 Prior to use, the particulate destabilizing agent advantageously is treated to assure
24 removal of all extraneous components that would cause initiation of polymerization. For
25 example, in the case of weak base anion exchange resin, it is treated with distilled water
26 followed by vacuuming to 0.20 mm Hg at 35-50 degrees centigrade.

27 The new method of the invention for curing stabilized cyanoacrylate adhesives
28 coincidentally with their application to a substrate is particularly useful in performing
29 medical procedures using such adhesives, e.g., suturing human or animal flesh, providing
30 wounds with protective covering, etc. However, it may be used in other adhesive
31 operations, e.g., joining plumbing items, forming furniture joints, etc.

The objects are further accomplished in accordance with the invention by the provision of unique devices for using the method of the invention. Advantageously, such device is one that (a) delivers the cyanoacrylate adhesive of convenient viscosity by some degree of partial polymerization and regulated by the interval from the destabilizing operation to time of application, (b) contains a porous segment for the containment of a frangible ampoule and other components so as to permit the release of the destabilized adhesive with no particulate components being released onto the substrate to which it is applied, (c) delivers the destabilized adhesive through a nozzle to an applicator tip configured for appropriate application onto the substrate, (d) is configured with the adhesive in an isolated compartment separate from the destabilizing agent(s), that is able to release contents into contact with the destabilizing agents, (e) positions the destabilizing component in a compartment through which the ampoule-released adhesive passes as it is being delivered to the applicator tip for transfer to the substrate and (f) can be used to destabilize monomer formulations prior to application to effect the desired result.

A preferred embodiment of a device of the invention comprises a syringe having an elongated tubular chamber defined by a length of flexible tubing having a proximal end and a distal end, a dispensing tip on said distal end, means at the proximal end to apply pressure to said chamber, filter means positioned between the dispensing tip and the chamber, a frangible ampoule located within the chamber contains stabilized cyanoacrylate adhesive and particulate destabilizing agent is contained in the chamber external of the ampoule.

In an alternate embodiment of the above described device, the particulate destabilizing agent is contained in the ampoule and the cyanoacrylate adhesive is contained in the chamber external of the ampoule.

All of the preferred embodiments are meant to further include all of the various additives useful in the alteration and improvements to cyanoacrylate adhesives as would make them suitable for placement into the above devices and modifications to these devices. These can include plasticizers, stabilizers, surface insensitive additives, tougheners, thickeners, adhesion promoters and other such compositions as would be evident to those familiar with the cyanoacrylate adhesives art.

1 BRIEF DESCRIPTION OF THE DRAWINGS

2 A more complete understanding of the invention can be obtained by reference to
3 the accompanying drawings in which:

4 FIG. 1 is a lateral view, partially in section, of a device used in accordance with
5 the invention for curing stabilized cyanoacrylate adhesives coincidently with their
6 application to a substrate.

7 FIG. 2 is a lateral view of second embodiment of the dispensing end portion of a
8 device as illustrated in FIG. 1.

9 FIG. 3 is a lateral view of third embodiment of the dispensing end portion of a
10 device as illustrated in FIG. 1.

11 FIG. 4 is a lateral view of fourth embodiment of the dispensing end portion of a
12 device as illustrated in FIG. 1.

13 FIG. 5 is a lateral view, partially in section, of another device used in accordance
14 with the invention for curing stabilized cyanoacrylate adhesives coincidently with their
15 application to a substrate.

16 DESCRIPTION OF PREFERRED EMBODIMENTS

17 With reference in detail to the drawings in which generic components are
18 designated by an arrowhead line and specific components by a plain line, FIG. 1 shows a
19 first embodiment of a device 2 of the invention for performing the new methods of the
20 invention comprising syringe 4 having a pliable tubular section 6 partially defined by a
21 proximal end 8 and a distal end 10 capped with a discharge member 12 defined by a dish
22 portion 12a and tapered portion 12b plus a funnel 12c structured to operatively engage
23 the tapered portion 12b.

24 A washer-like member 14 caps the proximal end 8 and admits a plunger 16 with a
25 distal end 17 that proximally defines a chamber 18. A filter disc 20 fixed in the distal end
26 10 distally defines the chamber 18 within the tubular section 6.

27 The chamber 18 encloses a frangible ampoule 22 and a quantity of particulate
28 destabilizing agent 24 as defined herein as an essential material of the invention. The
29 ampoule is precharged with an adhesive composition 26 comprising cyanoacrylate
30 adhesive and a stabilizing agent in accordance with the invention thereby being separated
31 from the particulate destabilizing agent 24 until such time as the ampoule 22 is
32 fragmented in carrying out the new method of the invention.

1 To accommodate different variations of adhesive application to substrates in
2 accordance with the invention, the discharge member 12 can be variously structured.
3 Thus, FIG. 2 illustrates a discharge member 12A similar to member 12, but having a
4 hemispheric porous filter tip 12d. Also in FIG. 3, the discharge member 12B has a
5 slotted end 12e to create a ribbon discharge of destabilized adhesive composition from
6 the device 2 and in FIG.4 the discharge member 12C has a nipple end 12f for drop
7 dispensing of destabilized adhesive composition.

8 FIG. 5 shows a second embodiment of a device 30 of the invention for performing
9 the new methods of the invention comprising syringe unit 32, a control valve 34
10 connected thereto by fluid line 35, a pressure source 36 connected to valve 34 by fluid
11 line 37 and a suction source 38 connected to valve 34 by fluid line 39. Advantageously,
12 valve 34 can be a foot operated type so a surgeon using the device 30 will have both
13 hands free in to apply destabilized adhesive composition to a substrate in accordance with
14 the invention.

15 Syringe unit 32 has a pliable tubular section 40 partially defined by a proximal
16 end bulb 42 and a distal end 44 capped with a nozzle 46.

17 A filter disc 48 is fixed in the distal end 44 and distally defines an operation
18 chamber 50 together with the tubular section 40 and the bulb 42. The chamber 50
19 encloses a quantity of particulate destabilizing agent 52 as defined herein as essential
20 material of the invention. In use, the syringe unit 32 will suck a suitable amount of
21 stabilized cyanoacrylate adhesive into the chamber from a container (not shown) through
22 nozzle 46 when the valve 34 connects line 35 to the suction source 38. By manipulation
23 of the pliable tubular section 40, indrawn adhesive (not shown) is mixed briefly with the
24 destabilizing agent 52. Then, valve 34 is carefully manipulated to intermittently connect
25 line 35 with the pressure source 36 to force resulting destabilized cyanoacrylate adhesive
26 out of the chamber 50 via filter 48 and nozzle 46 onto the relevant substrate under the
27 control, for example, of a surgeon. Following such an operation, the syringe unit 32 will
28 be disconnected from the line 35 and be discarded, while the remaining units 34, 36 & 38
29 will be retained for repeated use with new syringe units 32.

30 The following preferred examples further disclose the new method and display its
31 effectiveness. In these examples, all percentages are by weight unless otherwise
32 indicated.

1 EXAMPLE 1

2 A quantity of particulate destabilizing agent in the form of suspension type, weak
3 base anion exchange resin beads is treated with distilled water followed by vacuuming to
4 0.20 mm Hg at 35-50 degrees centigrade to remove volatiles and moisture.

5 Approximately 1.0 gram of iso-octyl cyanoacrylate monomer is sealed in a
6 frangible ampoule. Such cyanoacrylate monomer has been stabilized with hydroquinone
7 at 0.5%. The acid stabilizer, methane sulfonic acid, was introduced previously into the
8 cyanoacrylate monomer during its synthesis at 0.25%. The cyanoacrylate monomer in the
9 ampoule and approximately 1.0 gram of the treated anion exchange resin are individually
10 introduced into a tubular device referred to as a Tandem Dropper supplied by James
11 Alexander Company of Blairstown, New Jersey, that also provided unsealed ampoules.

12 In order to filter matter dispensed from the dispenser tip of the Tandem Dropper,
13 it is plugged internally with a small wad of polyester fiber also supplied by James
14 Alexander Company. The dispenser tip press fits onto the end of the Tandem Dropper to
15 contain the destabilizing agent and ampoule. The assembled device is activated by
16 crushing the ampoule. The resultant mixture is then thoroughly mixed by shaking so as to
17 obtain optimal exposure of monomer to the destabilizing agent. Then, a plurality of
18 spaced apart drops of the resulting destabilized adhesive are applied to human skin on the
19 back of a hand and the time for the resulting films to undergo cure to a non-tacky
20 surface is determined. The destabilized adhesive undergoes cure in 5-15 seconds upon
21 application to the skin. This contrasts with untreated iso-octyl cyanoacrylate monomer
22 which shows no sign of cure in 3 minutes.

23 EXAMPLE 2

24 A two milliliter plastic dispensing pipette is cut at the bulb end to permit charging
25 of destabilizing agent. The pipette is a Number 3 obtained from Poly-Pipets,
26 Incorporated of Englewood Cliffs, New Jersey. A ¼ inch polyester fibrous plug as
27 described in Example 1, is inserted down into the narrow tip portion and then 0.5 grams
28 of anhydrous granular potassium carbonate are charged into the pipette. The plug acts as
29 a filtration barrier to contain the granular potassium carbonate.

30 The bulb end of the pipette is heat sealed and the resultant device is used to
31 suction about 1 milliliter of iso-octyl cyanoacrylate monomer for mingling with the
32 enclosed particulate. The device is positioned with the tip vertically upward and the

1 components are intermingled by successive squeeze and release actions for a short period
2 of time. Upon satisfactory mixing, the unit is used to apply the resulting destabilized
3 adhesive onto to skin as thin film portions on the back of a hand. It is determined they
4 undergo cure in 5-15 seconds. In contrast, untreated iso-octyl cyanoacrylate monomer
5 exhibits no signs of curing for periods of 3 minutes.

6 This example illustrates the use of multiple applications of the adhesive from a
7 supply of adhesive and disposable pipettes and foregoes the need for a frangible ampoule
8 or other adhesive-isolating device.

9 EXAMPLE 3

10 A test was conducted on a wound accidentally caused by a hot surface to the
11 inside of the left forearm. The wound, approximate dimensions of ¼ inch by 1.5 inches,
12 had begun to slough off the burned skin exposing the underlying tissue. To evaluate the
13 protective effect of the destabilized liquid adhesive, the device of Example 2 was used to
14 apply destabilized iso-octyl cyanoacrylate adhesive. The wound was overlayed with a
15 thin film and cure took place in the 15-30 second range. The applied and cured
16 cyanoacrylate adhesive remained well attached for a period of days to the injured skin
17 while it served to protect the covered wound area from irritation and infection by clothing
18 or other contact as well as promote the healing process. This contrasted with prior
19 experiences of similar wounds where the damaged tissue did not heal well due to physical
20 contact with surrounding irritants such as clothing or other contact surfaces.

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